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The Biathlon Injury and Illness Surveillance (BIIS) project protocol: a prospective cohort study across two World Cup seasons

Jane Fitzpatrick [1,2] Nirmala Panagodage Perera [3,4]

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For numbered affiliations see end of article.

Correspondence to
Jane Fitzpatrick; jane.fitzpatrick@unimelb.edu.au

ABSTRACT

Introduction Reliably and accurately establishing injury and illness epidemiology in biathletes will provide insight into seasonal changes, provide potential to better embed innovative prevention strategies and advance sports medicine through the provision of effective healthcare to biathletes. The main objective of the Biathlon Injury and Illness Study (BIIS) is to provide the first comprehensive epidemiological profile of injury and illness in biathlon athletes during two consecutive Biathlon World Cup seasons over 2-years.

Methods The BIIS study methodology is established in line with the International Olympic Committee (IOC) injury and illness surveillance protocols using a biathlon-specific injury and illness report form. Team medical staff will provide weekly data using injury and illness definitions of any injury or illness that receives medical attention regardless of time loss. Injuries or illness must be diagnosed and reported by a qualified medical professional (eg, team physician, physiotherapist) to ensure accurate and reliable diagnoses. Descriptive statistics will be used to identify the type, body region and nature of the injury or illness and athlete demographics such as age and gender. Summary measures of injury and illnesses per 1000 athlete-days will be calculated whereby the total number of athletes will be multiplied by the number of days in the season to calculate athlete-days.

Ethics and Dissemination This study has been approved by the Bellbery Human Research Ethics Committee (HREC reference: 2017-10-757). Results will be published irrespective of negative or positive outcomes and disseminated through different platforms to reach a wide range of stakeholders.

What has been done in this field to date

- IOC epidemiological data from Winter Olympic Games shows a 7% injury rate in athletes
- An IBU study in Biathlon shows 41% of biathletes had an injury in the preceding 12 months.

What will be the impact of this research

- Prospective data will determine injury and illness rates across athletes' competitive seasons.
- Knowledge of illness and injury rates creates potential to intervene to reduce lost days for example with vaccinations to reduce rates of influenza.

INTRODUCTION

Since its Olympic debut at the 1960 Squaw Valley Winter Olympic Games, biathlon has become an internationally competitive winter sport, with equal participation by men and women at the International level. Currently, 55 countries are registered with the International Biathlon Union (IBU).[1] Biathlon requires skill and endurance as it combines the calm and precision of intermittent marksmanship with the aerobic demands of cross-country skiing. In 1985, skating was chosen as the mandatory technique for skiing in biathlon to increase the velocity and the dynamic nature of the sport. Significant training demands (eg, high training loads and repetitive training) are placed on elite biathletes throughout the year. Time lost to injury and/or illness can influence success or failure of biathletes as their availability to train is affected[2 3]; thus, protecting their health should contribute to improved performance and increased chance of success.

Sports injury and illness surveillance is the first step of any prevention programme,[4 5] yet there is a paucity of research on health issues in biathletes. Existing evidence from the Vancouver,[6] Sochi[7] and PyeongChang[8] Winter Olympic games demonstrated variable injury rates (medical attention injuries) from 1% in 202 biathletes in Vancouver,[6] to 7% in 204 biathletes in Sochi.[7] One in seven (14%) injuries in Sochi occurred in training[7] whereas in Pyeong Chang only 2% of injuries occurred in training.[8] A cross-sectional study commissioned by the IBU Medical Committee found at least one musculoskeletal injury was reported by 41% of the 116 biathletes

during the year preceding the survey (incidence =586 injuries per 1000 athletes per year).[9] Similar to a study cohort of cross country skiers,[10] female biathletes reported more injuries than males (55% vs 40%).[9]

Recognition of the role of illness is growing in sports medicine, for instance, physiological changes associated with acute infective illness impair motor coordination, decrease muscle strength,[11] reduce peak V02 (peak oxygen consumption) and endurance capacity and change metabolic function,[12] consequently affecting biathletes ability to train, compete[2] and perform well.[2] Our current understanding of illness rates is limited to data from Winter Olympic Games (11% in Vancouver,[6] 10% in Sochi[7] and 15% in Pyeong Chang.[8]) Like injury data, no longitudinal studies in cross country skiing or biathlon are currently available to explore the impact of illness on these athletes. In other sports, illness prevalence increases with a longer duration of tournaments[13] and international travel increases the risk of illness.[14 15] Biathletes could be exposed to multiple risk factors during the 3-month season involving weekly international travel during the winter.[14 15] The World Cup consists of 3 trimesters and a high load with weekly competitions. There is one travel day each week and a Christmas break of 2 weeks. In alternate seasons, there may also be races in North America or Asia, requiring travel to and from Europe, often towards the end of the season. This race series puts a high demand on the athletes from both competition and travel-related positions. To address the limitation in existing evidence, the Biathlon Injury and Illness Study (BIIS) was developed by the IBU Medical Committee to prospectively collect injury and illness data during two Biathlon World Cup seasons. Reliably and accurately establishing injury and illness epidemiology in biathletes, would provide insight into seasonal changes, better embed innovative prevention strategies and advance sports medicine through the provision of effective healthcare. Therefore, the main objective of the BIIS project is to provide the first comprehensive epidemiological profile of injury and illness in biathlon athletes during two Biathlon World Cup seasons for a period of 2-years. The starting date for this project has been delayed due to the impact of the COVID19 pandemic on the sport of Biathlon. It is envisaged that the study will commence in 2022 but is dependent on the normal resumption of competition.

The specific aims are to:

a) provide an epidemiological profile of the nature, incidence and prevalence of injuries and illness in biathlon athletes;
b) identify when injuries and illnesses are most likely to occur (eg, training vs competition, early vs late season);
c) identify who is most at risk (eg, female vs male athletes, older vs youth athletes, vaccinated vs non-vaccinated).

METHODS

The BIIS study methodology and procedures are established in line with the International Olympic Committee (IOC) injury and illness surveillance protocols.[6 16 17] A biathlon-specific injury and illness report form (based on forms used in the Sochi Winter Olympics[7]) in English, French, German and Russian was developed during Phase 1 of the BIIS project with input from the team medical staff[18] and will be used for data collection. This is included in the supplemental materials.

Definition of injury and illness

The IOC consensus statement defines injury is defined as 'tissue damage or other derangement of normal physical function due to participation in sports, resulting from rapid or repetitive transfer of kinetic energy.'[19] The same definition of injury will be adopted for this study and data will be collected from:

- any injury that receives medical attention regardless of the outcome,
- newly occurring injuries,
- training or competition injuries.

'Subsequent injuries to the same location and tissue as the index injury are recurrences if the index injury was healed/fully recovered; they are exacerbations if the index injury was not yet healed/fully recovered.[19]' Pre-existing or incompletely rehabilitated injuries will not be included. Recurrent injuries (to the same anatomical location and type) will only be included if the athlete is fully recovered after their previous injury and returned to full biathlon participation. The IOC consensus statement defines illness as 'a complaint or disorder experienced by an athlete, not related to injury. Illnesses include health-related problems in physical (eg, influenza), mental (eg, depression) or social well-being, or removal or loss of vital elements (air, water, warmth).'[19] Same definition of illness will be adopted and data will be collected from:

- all illnesses that receive medical attention, whether or not they result in time loss,
- newly acquired illness,
- 'subsequent illnesses to the same system and type as the index illness are recurrences if the individual has fully recovered from the index illness, and exacerbations if the individual has not yet recovered from the index illness.[19]' Chronic or pre-existing illnesses will not be reported, except in the event of an acute exacerbation. For example, if a biathlete has asthma, this should not be recorded unless there is an acute exacerbation of asthma or there is a new diagnosis of asthma.

When an athlete is available to train and compete then after an injury or illness, it is considered completely healed or fully recovered.[19]

Rationale for injury and illness inclusion criteria

The advantage of using a broad definition of medical attention injury and illness is that the effect of the full spectrum of injuries can be assessed, for example, from mild sprains to ligament ruptures and illnesses from the common cold to pneumonia. Since athletes may compete despite an injury or illness, using only a time loss

definition may not be sufficient to capture all injuries. Further, broad injury and illness definitions removes the onus from team medical staff to judge which injury or illness should be included in the surveillance. Collating information relating to time loss enables calculation of incidence of time loss injuries or illness to compare against studies that use similar time loss definition and compare the impact of these injuries and illness on athlete availability. Consistent with previous studies, pre-existing, not fully rehabilitated injuries, recurrent injuries and chronic illness will not be reported.[7 8]

Study period and population

Data will be prospectively collected from the athletes by their team medical staff (eg, physicians and physiotherapists) during two Biathlon World Cup seasons for a period of 2-years. The start date is yet to be determined but is anticipated to be after 2022 due to COVID-19 pandemic. All injuries and illnesses that occur from the start of the season to the finish of the season will be included. This includes all training and competition days as well as days in travel or days off. It is anticipated that 120–140 athletes representing 25 countries will be competing during each World Cup Season during the BIIS project. All athletes who participate in any of the World Cup events will be included regardless of age, gender or other demographics.

Data collection

Weekly injury and illness report forms will be submitted by the team medical staff via electronic return submission (embedded in the PDF forms) to an encrypted electronic storage box at the IBU Head Office in Salzburg. The principal investigator (JF) will be the only person with access to this passcode. Injury data will include information relating to location and type of injury, injury mechanism, training or competition injury and time loss (online supplemental appendix 1). The injured body part can be recorded by describing injury location and supplemented by respective 28 code(s) using injury locations specified on the back of the injury and illness report form. Similarly, the type of injury (diagnosis) can be described by respective 20 code(s) of the injury types. Injury mechanism/cause of injury is described in words with the use of 12 respective codes. Injury mechanism/cause is important for injury prevention, thus a broad spectrum of injury mechanisms/causes will be included as listed below.

- Traumatic injury—mechanism/cause of the injury a specific, identifiable event.
- A recurrent injury (re-injury)—injury occurred after biathlete return to sport from a previous to the same anatomical location.
- Overuse injury—injury occurred without a single identifiable cause and may be due to the repeated micro-trauma.
- Non-contact trauma—injury occurred from a traumatic event without contact with another athlete, a moving object (eg, ski, ski pole and rifle) or a static object (eg, netting or course fencing, tree).
- Course conditions (eg, uneven ground, ice or soft snow).

The duration of absence from sport is an indicator of injury severity. Team medical staff are asked to estimate time loss (ie, number of days biathlete will not be able to train or compete). When multiple injuries occur from one injury event, injury severity will be based on the injury casing the longest time loss.[19]

The illness data will include diagnosis, main symptoms and affected system, cause of illness and time loss from the sport. The team medical staff will be asked to describe the type of illness using 12 respective codes. Similarly, symptoms will be described and supplemented by 13 respective symptom codes. Time loss from sport will be estimated and the medical staff will have the opportunity to revise estimates of time off subsequently, if required.

Body area categories and tissue-type and pathology-type categories and illness categories for organ system and aetiology recorded by the biathlon-specific injury and illness report form are in line with IOC consensus statement recommendations.[19]

To ensure valid information on the injury or illness characteristics and comparable standard of data, a qualified medical professional (eg, team physician, physiotherapist) will diagnose and report all injuries and illnesses. The designated contact person will be recommended (eg, chief medical officer of the national team) and will take part in the instructional meeting, be responsible for weekly reporting of all new injuries or illnesses, which have occurred during training or competition (or the non-occurrence of injuries and or illness) via web-based injury and illness report form. If the diagnosis or time loss is revised (eg, further diagnosis or treatment), then the injury or illness will be reported again with the corrected information accompanied by previous data and a clear indication that this is a revised report.

The number of biathletes in a team for a given week and the number of biathletes in a team for the whole season will be collected with each weekly injury and illnesses report. Typically, the race organisers or IBU have a database with information on event, accreditation number, sex, date of birth, and country of all registered biathletes. Athlete accreditation number will be used to avoid replicating of injuries or illness reports and to track updated reports with revised information about a reported injury or illness. To protect the privacy of all athlete data, the accreditation number will be replaced by a unique study identifier code within the BIIS database. All data extraction will be done with de-identified data.

Data analysis

Descriptive statistics will be used to identify the type, body region and nature of the injuries or illness reported and will be presented as absolute values or percentages of the total (for categorical variables) and means and SD (for

continuous variables). The average weekly injury and illness prevalence will be calculated by dividing the number of weeks a biathlete reported injury or illness by the total weekly reports for that biathlete. The injury and illness incidence will be calculated using the following formula with incidence proportions presented as injuries or illnesses per 1000 athletes.

$$Injury/illness\ incidence = \frac{number\ of\ injuries\ or\ illness\ during\ the\ study\ period}{number\ of\ exposed\ (participating)\ athletes}$$

Injury and illness burden will be calculated using the following formula: mean severity (number of days lost before full return to training/competition) x injury incidence.

$$Injury\ and\ illness\ burden = mean\ severity\ (number\ of\ days\ lost\ before\ full\ return\ to\ training/competition)\ x\ injury\ incidence$$

The injuries with the largest burden will be plotted in an injury risk (burden) matrix, where the mean injury severity (time-loss days) is plotted against the injury incidence.

Summary measures of injuries and illnesses per 1000 athlete-days (exposure-time-related incidence) will be calculated; the total number of athletes will be multiplied by the number of days in the season to calculate athlete-days. Ideally, Poisson or a negative binomial model will be required to analyse trends in the number of cases per year to determine their statistical significance and the percentage increase/decrease of participant-adjusted injury and illness rate over time.[20] As recommended region and type and diagnosis will be combined for injuries and system/region and aetiology combined for illness when the data will be reported as recommended by the consensus statement.[19]

To identify who is most at risk, the CI (CI) of the risk ratios (RR) of the number of injuries or illnesses between two groups (eg, female vs male athletes, older vs youth athletes, vaccinated vs non-vaccinated, training vs competition, early vs late season) will be calculated using a Poisson model and constant hazard per group will be assumed. Injury and illness incidence will be reported as mean and RR with 95% CI. Two-tailed p values ≤0.05 will be considered statistically significant.

The validity of Poisson or a negative binomial model of injury or illness trends over time is dependent upon sample size. If a small number of annual injuries or illnesses reports will violate the assumptions of these statistical models, the coefficient of determination (r2) of a straight-line will be calculated to graphically demonstrate the trends in participation-adjusted injury and illness rates over 2-years.

Quality assurance

The principal investigator (JF) will co-ordinate a team medical staff briefing at the first three World Cup events to ensure all participating team medical staff are aware of the protocol and have the opportunity to discuss it. This will be repeated at alternate events for the remainder of the season. A brochure will be provided to the team medical staff to describe the protocol and the nomenclature on the forms. Each form collected weekly will be reviewed by the principal investigator (JF) and discussed with the relevant team medical staff member if there are any apparent anomalies.

Patient and public involvement

Patients (ie, biathletes) were not involved in planning, design or conduct of the BIIS project. Medical staff (public) were involved in all stages of the design and planning of this protocol by way of engagement in Phase I—where the forms and questions were identified and in the testing of forms for use in this study.[21] Biathletes and the public will be involved to assist with dissemination and evaluation of the BIIS results.

STRENGTHS AND LIMITATIONS

This study will adopt a sport-specific version of the IOC injury and illness surveillance forms[18] and retain the coding system previously used for the IOC surveillance projects,[7] allowing direct comparison with data collected at previous Winter Olympic Games. The injury and illness surveillance form is available in the four most commonly used languages in biathlon[18] which enable appropriate data collection from a non-English-speaking population. Consultation with the IBU medical committee and team physicians should ensure the relevance of the BIIS project and buy-in from biathlon federations thereby assuring the longevity of the project. Data will be collected during the competitive seasons over a 3-month period, thus injury and illness data during the off-season will not be collected. Owing to practicality, workloads, sleep, recovery are not monitored as part of this project and could limit the validity of the results.

ETHICS AND DISSEMINATION

The study received the ethical approval from the Bellbery Human Research Ethics Committee (HREC reference: 2017-10-757). Any information we collect which could identify athletes will remain confidential, restricted and athlete confidentiality will be maintained at all times. All data will be made anonymous by using a unique study identifier code within the BIIS database and the athlete accreditation number will not be entered into the injury and illness database. The unique identification number will enable data to be collected in a format that is re-identifiable to the principal investigator (JF), and research assistant from IBU office but will be non-identifiable to the research team.

In instances where it is not possible to document the athlete accreditation number owing to legal issues in

some countries, the team will create a unique identifier code for the athletes in their teams. This unique identification number will also be kept separate to the main data set and data will be kept anonymous to maintain confidentiality.

Access to raw data will be restricted to those directly involved in the administration of the project. This is expected to be limited to the principal investigator (JF) and the research assistant from the IBU office in Austria who provide administrative support by managing the source data. Team medical staff will not have access to the source data but a summary of their team's data will be made available to them. The database will be de-identified after the study period to ensure the anonymity of all biathletes.

Consent forms will not be required from the participating team medical staff, as the submission of injury reports represents implied consent. The BIIS project has approval from the IBU Executive Board. All teams competing in the two World Cup seasons will be requested to participate in the injury surveillance project prior to the start of the project. In order to meet the transparency principle of the GDPR, Article 12(1) requires data controllers (the IBU) to notify data subjects (athletes) of the processing of their personal data. This will be done by way of privacy notice provided with the athlete registration forms and will set out an individual's rights in respect of that personal data, such as their right of access or to amendment where it is inaccurate. The consent process and data handling requirements will be reviewed to ensure they meet all privacy requirements in the appropriate jurisdictions.

Regardless of negative or positive outcomes, findings will be published in peer-review journals and presented at scientific conferences. A report on the key findings will be provided to the IBU Executive Board to inform their ongoing international leadership in this area. In addition, a report will be submitted to the IOC Medical and Scientific Commission. Recommendations will be provided to the IBU and the IOC about improvements to current and future guidelines, to maximise the impact of the health and well-being of biathletes and other athletes participating in winter endurance sports. The results of this Phase II study will inform the implementation of evidence-based strategies to reduce injuries and illness the incidence (a potential Phase III study). A multimodal approach for dissemination and knowledge translation (eg, animations, blogs, infographics, and podcasts) will be used to disseminate and communicate results to study participants, general public and other stakeholders via different outlets (social media platforms and mass media).

Author affiliations
[1]Centre for Health and Exercise Sports Medicine, The University of Melbourne Faculty of Medicine Dentistry and Health Sciences, Melbourne, Australia
[2]Research Committee, Australasian College of Sport and Exercise Physicians, Melbourne, Australia
[3]Unit of Physiotherapy, Department of Health, Medicine and Caring Sciences (HMV), Linkoping University Department of Medical and Health Sciences, Linkoping, Sweden
[4]Centre for Sport, Exercise and Osteoarthritis Research versus Arthritis, Oxford University, Oxford, UK

Twitter Jane Fitzpatrick @sportsdocaus.

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Competing interests NPP declares no competing interests. JF is the Medical Director for the Australian Biathlon Association and has previously served as a member of the Medical Committee for the International Biathlon Unio.

Ethics approval Ethics approval was obtained from the Bellbery Human Research Ethics Committee (HREC reference: 2017-10-757).

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ORCID iDs
Jane Fitzpatrick http://orcid.org/0000-0002-9578-026X
Nirmala Panagodage Perera http://orcid.org/0000-0001-6110-8945

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